

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

11620
21723
U. S. Department of Agriculture - Forest Service
CENTRAL STATES FOREST EXPERIMENT STATION
Columbus, Ohio

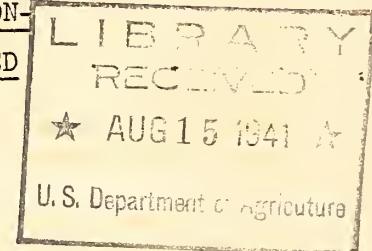
Technical Note 34

July 15, 1941

FOREST SOIL PROPERTIES ASSOCIATED WITH CON-
TINUOUS OAK, OLD-FIELD PINE, AND ABANDONED
FIELD COVER IN VINTON COUNTY, OHIO

By

John T. Auten, Silviculturist



Deterioration of cleared land by erosion of surface soil has been recorded in diminishing crop returns and land abandonment. Destruction of litter and forest soil structure, soil compaction, and critical reduction in rate of water absorption have made regeneration of hardwoods difficult on many abandoned areas.

Regeneration of hardwood forests is coincident with and dependent on rebuilding the forest soil. The degree to which a litter cover is restored, cessation of erosion, increase in water absorption, and amelioration and enrichment of the surface soil with humus are of interest as evidences of soil recovery. This paper deals with such indications of soil building as they were determined on an area in Vinton County, Ohio.

A resident who had lived nearby for nearly 80 years observed the area through the entire process of clearing, farming, abandonment, and regeneration to pine. He had harvested wheat, thinned a young stand of pine and later cut logs off the same area. He said when the pine seedlings produced by natural seeding from 3 or 4 old trees were 4 or 5 feet high one could stand almost anywhere among them and touch several at once. At present there are about 250 pine stems per acre with an understory of native hardwoods coming in under the mature pines. Healed gullies are still evident in the shortleaf pine area, indicating destructive erosion after abandonment. The crown canopy is completely closed.

Adjacent to the shortleaf pine stand was an old field recently abandoned and covered with weeds. Since the two areas have the same or very similar soil types and since the histories of their uses have been so nearly alike except that one was forested, they offered opportunity for comparison regarding soil conditions.

Nearby was a stand of second-growth chestnut oak. Cutting has been consistently practiced in this stand as the trees grew large enough for cross ties. Fires have been recurrent as evidenced by scars, but at the time it was examined the area had not been burned for at least 4 or 5 years. Accumulated litter was intact for that period except for normal decomposition. The crown

canopy was about 80 percent closed. The soil had not been disturbed except for diminution of total organic matter added in the litters of previous years. The site is a little higher than the old field and the shortleaf pine stand. The soil is the same except it contains a little more sand than that of the old field and the shortleaf pine areas.

A second-growth white oak stand with history comparable to that of the chestnut oak was used as a further basis of comparison. It occurs on the same type of soil as that supporting the shortleaf pine. The stand was not quite so complete as that of the chestnut oak but still fair. The crown canopy was about 60 percent closed. Cutting has probably been a little more severe because of the more desirable quality of the timber.

These four sites together with a second abandoned field used for additional porosity and water infiltration data form the basis of this study. The results secured are comparative in nature. No data are available on the soil of any of the sites in their original state. That the sites are located in the same area, have similar histories and are representative of the condition of a great deal of land in eastern Ohio lends value to the comparisons made.

Recovery from erosion on cleared areas in this region was probably more rapid than it has been in some others. Tillage was continued until farming became unprofitable as elsewhere, but regeneration of forests has been easier. The soils are principally Muskingum and Wellston silt loams, with the Muskingum series predominating. The Muskingum is a loose, well-drained soil without a very pronounced B or subsoil horizon. The Wellston has a subsoil but its drainage is good. These soils erode easily and removal of the entire A horizon is common on steep slopes, but when the surface soil is gone a porous subsoil is exposed. An eroded Muskingum soil retains much of its soil porosity, hence forest rehabilitation has accordingly followed abandonment with greater success.

Table 1 gives stem numbers and total basal area for shortleaf pine, chestnut oak and white oak plots. The only record available regarding timber taken off the area was the owner's statement that he had cut 4 carloads of logs off the 20-acre shortleaf pine tract. The total basal area of the pine stand exceeds that of the chestnut oak. The white oak stand has about 50 percent as great a basal area. It is interesting to observe that hickory forms a large part of the hardwoods which have regenerated under pine. One yellow poplar has entered the dominant stand. The cycle from hardwoods, through cultivation and abandonment, to regeneration of hardwoods is almost complete.

Litter

The quantity of litter accumulated under the 3 forest stands was found by removing and burning off 10 dried 1-foot square samples from each. The loss-on-ignition weights representing combustible and volatile organic matter when converted into pounds per acre was 26,968, 19,661 and 14,400 pounds respectively for shortleaf pine, chestnut oak and white oak stands. If litter weights for the oak sites are adjusted to unity as representing what they would be with full crown density they become 26,968, 22,076 and 24,000 pounds per acre, respectively. In 65 years from abandonment, the shortleaf pine site acquired a greater accumulation of litter than either of the permanent hardwood sites.

Table 1.--Species, basal area, and number of trees per acre on shortleaf pine, chestnut oak, and white oak plots.

SHORTLEAF PINE PLOT

Species	Basal area			Trees		
	Dominant	Co-dominant	Intermediate	Total	Dominant	Intermediate
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	No.	No.
Shortleaf pine	66.98	32.76	9.98	.52	110.24	131
Pignut hickory		.72		5.90	6.62	82
Mockernut hickory		1.37		3.82	5.19	4
Minor species ^{2/}						4
Black gum				1.97	1.27	4
Yellowpoplar						4
Shagbark Hickory						4
Total per acre	69.36	34.85	11.95	20.36	136.52	135

CHESTNUT OAK PLOT

Species	Basal area			Trees		
	Dominant	Co-dominant	Intermediate	Total	Dominant	Intermediate
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	No.	No.
Chestnut oak	15.61	11.65	9.08	2.70	39.04	25
White oak	11.23	3.81	6.09	1.43	22.56	17
Black oak	5.79	6.72	1.27	.54	14.32	6
Scarlet oak	2.09	.89		.25	3.23	2
Mockernut hickory	1.08	.93	3.33	1.49	6.83	2
Minor species ^{3/}						4
Total per acre	35.80	24.00	19.77	8.37	87.69	52

WHITE OAK PLOT

Species	Basal area			Trees		
	Dominant	Co-dominant	Intermediate	Total	Dominant	Intermediate
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	No.	No.
White oak	13.30	20.31	6.67	7.92	48.20	31
Chestnut oak	4.33	3.80	1.71	1.43	11.27	8
Black oak			4.77		4.77	
Scarlet oak	6.01				6.01	8
Pignut hickory						4
Rod maple						4
Minor species ^{4/}						4
Total per acre	23.64	24.11	14.58	11.80	74.13	47

^{1/} Data supplied by L. F. Kellogg, silviculturist, Central States Forest Experiment Station.

^{2/} Dogwood, sugar maple, sassafras, and black oak.

^{3/} Pignut hickory, dogwood, sassafras, red maple and service tree.

^{4/} Sugar maple, white ash and dogwood.

Nitrogen content of the litter of these forest stands followed roughly in quantity the weights of combustible material. Analysis of 10 litter samples from each stand gave as averages 409 pounds, 377 pounds, and 227 pounds nitrogen per acre, respectively, for shortleaf pine, chestnut oak and white oak. The re-establishment of litter on the shortleaf pine area is apparent both in total weight and in total nitrogen per acre. This should not be attributed altogether to the pine needle litter, however, because a considerable proportion of the litter was composed of the leaves of hardwood species in the understory. Figure 1 illustrates graphically the weight relations of litter and total nitrogen per acre for the 3 forest stands.

Organic Matter Incorporation

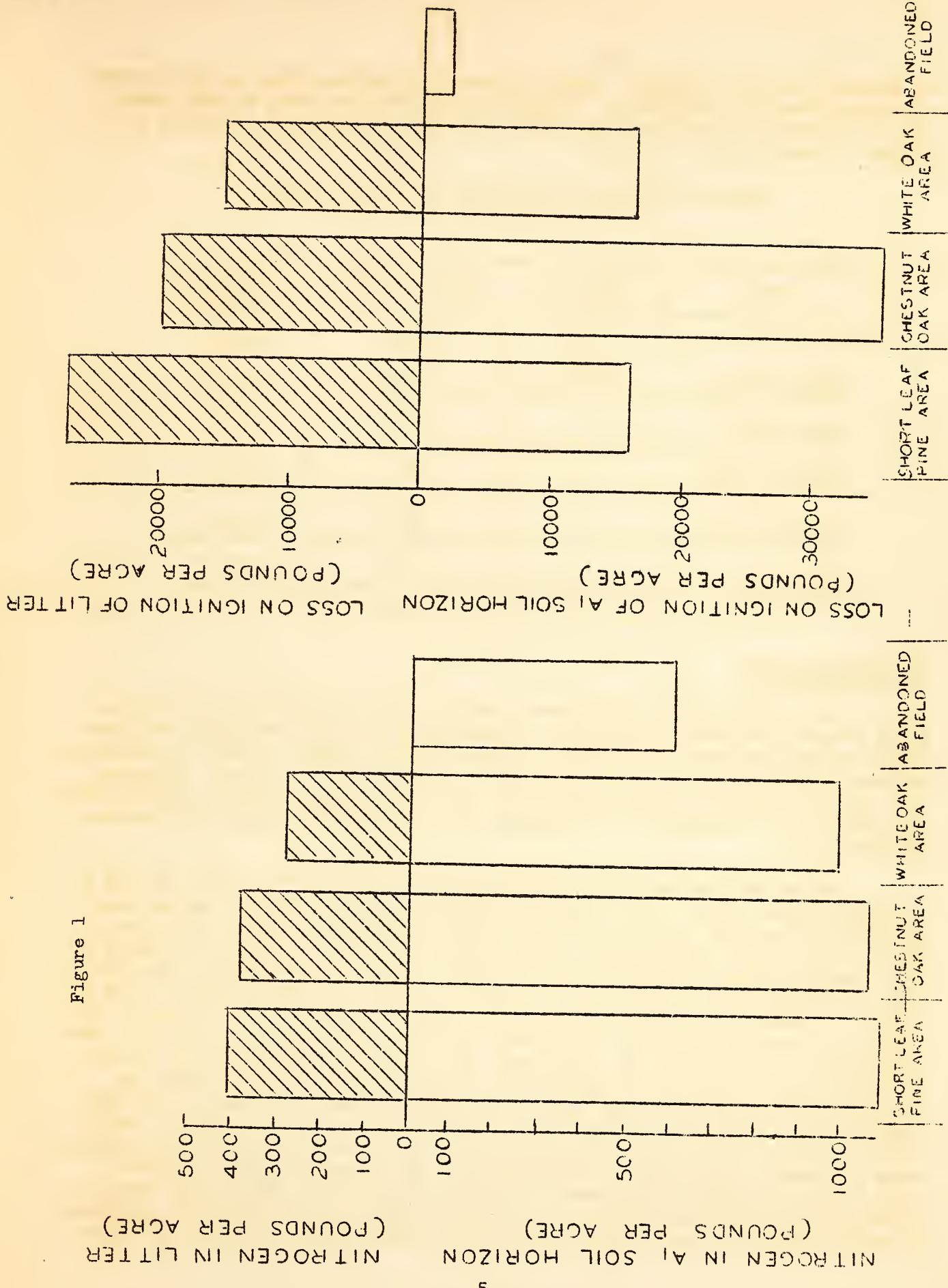
The total quantity of organic matter incorporated in the upper mineral soil of the 3 forested areas and 1 of the abandoned field areas was determined by igniting 10 surface soil samples from each. To eliminate error attributable to loss of combined water from the mineral soil, 10 samples from the A_2 horizon (that layer immediately under the darkened layer) were also ignited. It seemed reasonable to assume that the mineral soil in other respects than organic matter was relatively homogeneous in the surface and sub-surface horizons. Hence, by subtracting the loss of the A_2 from the loss of the A_1 the difference represented organic matter only. The net accumulations of organic matter in pounds per acre were 16,099 pounds, 35,620 pounds, 16,479 pounds, and 2,361 pounds per acre, respectively, for the shortleaf pine, the chestnut oak, the white oak areas and the abandoned field. The interesting observation here is the fact that organic matter accumulation in shortleaf pine soil is approximately equal to that in the second-growth white oak soil. The outstanding contrast in the comparison is the very small amount of organic matter in the soil of the abandoned field. If the soil of the abandoned field upon which the shortleaf pine regenerated was the same as that of the abandoned field adjacent to it, there is represented an increment of approximately 14,000 pounds of organic matter per acre under the shortleaf pine.

When total nitrogen in pounds per acre in the A_1 horizon is compared for the forest sites and the abandoned field site, there is a significant difference between the contents of the forest soil and the field soil. For instance, the quantities of nitrogen per acre were 1,070 pounds, 1,066 pounds, 989 pounds, and 604 pounds, respectively, for the shortleaf pine, chestnut oak, and white oak stands, and the abandoned field. Figure 1 illustrates graphically the varying weights of incorporated organic matter and nitrogen in the A_1 soil horizons of the different sites. There was pronounced accumulation of nitrogen both in the litter under the shortleaf pine and in the mineral soil.

Soil Porosity

Soil porosity probably is lowest at the time of land abandonment. Under forest cover it gradually increases. In the forest stands and in the adjacent fields of the experimental areas the relative weights of the respective soils were determined by driving $2\frac{1}{2}$ -inch steel cylinders into the upper soil, digging them out, and ejecting, drying, and weighing the soil cores. One hundred soil cores, $2\frac{1}{2}$ inches in diameter and 6 inches deep, were taken from each of the forest sites and the abandoned field site. For the sake of comparison a second

Figure 1



abandoned field was included. Table 2 gives the complete data on soil weights and calculated soil porosities. Differences in field weights of soil cores and in calculated porosities are small. The maximum difference between any 2 samples is only about 7 percent.

Table 2.-- Weight and porosity of two abandoned field and three forest soils

Site	: Volume of soil core	: Air-dry weight of soil core	: Soil porosity
	: C. c.	: Grams	: Percent
Open field 1	: 482.59	: 701 1/	: 44.58
Open field 2	: "	: 704	: 44.35
Shortleaf pine	: "	: 661	: 47.75
Chestnut oak	: "	: 610	: 51.76
White oak	: "	: 640	: 49.39

1/ Real specific gravity mineral soil 2.62.

Infiltration Rate

The really important difference between forest and field soil lies in their rates of rainfall absorption. Destruction of litter and upper soil porosity coincident with clearing and cultivation may render rainfall absorption inadequate for regeneration and growth of a hardwood forest stand. Clearing and cultivation make the site a dry one. Because of this critical dryness, the best measure of recovery of an abandoned site is its improvement in water-absorption rate.

Infiltration rates were tested on each of the 3 forest sites and the 2 abandoned field sites. Brass tubes, 2 inches in diameter and 12 inches long, were driven into the soil to a depth of about $\frac{1}{2}$ inch. The tubes were then filled with water and recession of the water level measured after 2 minutes in the woods and after 10 minutes in the field. Recession was slow in the field, hence a longer time was necessary in order to allow a readable volume to be absorbed. Sometimes recession of the water level was so rapid in the woods that it was necessary to make the measurement period much less than 2 minutes. The differences in rates must be considered, of course, only comparative, and not comparable to rainfall. The tubes had a 12-inch water head, and since the area upon which the water was applied was small and the surrounding soil dry, considerable lateral movement of water occurred. One hundred separate tests were made on each site. The infiltration rates were reduced to cubic centimeters per minute and analyzed statistically. The rates for forest differed from fields with high significance. Figure 2 illustrates graphically the infiltration rates of the 5 sites. It is interesting to note the great increase in infiltration rate associated with a very slight increase in soil porosity.

400

INFILTRATION PER MINUTE (CUBIC CENTIMETERS)

300

200

100

0

PLOT NUMBERS

1 2 3 4 5

OLD-FIELD PINE

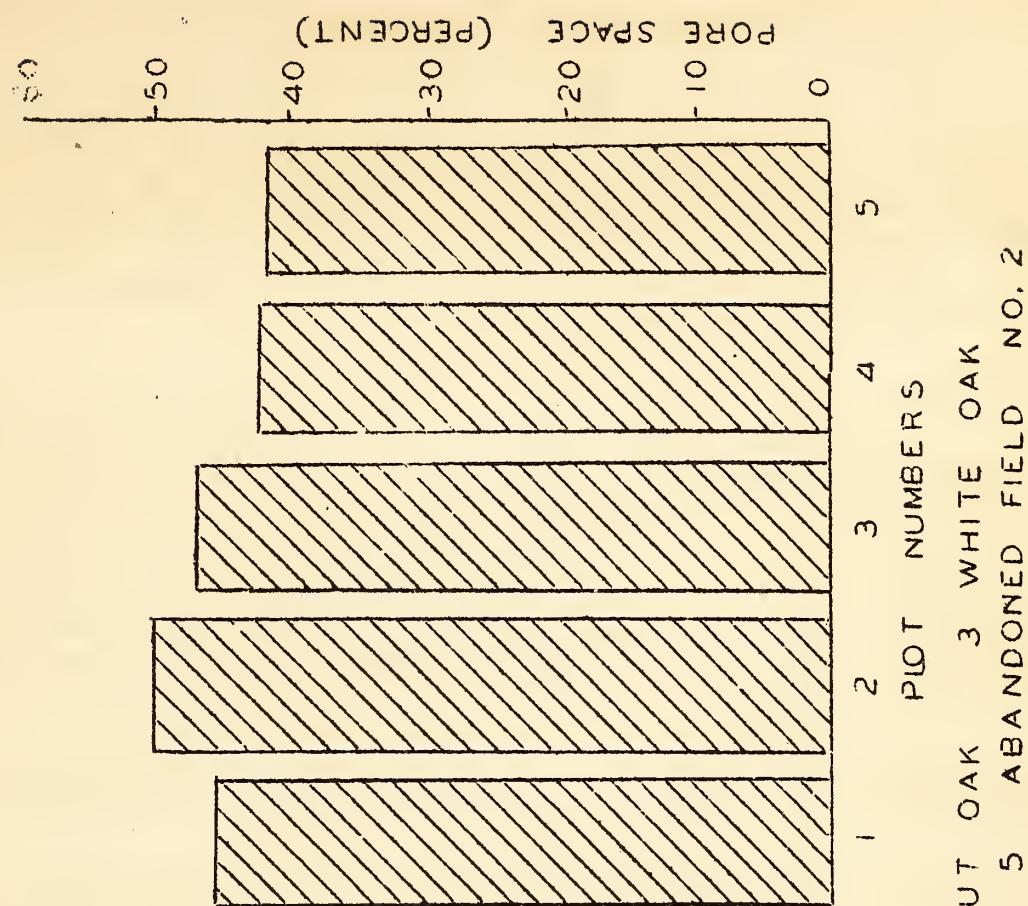
2 CHESTNUT OAK

3 WHITE OAK

4 ABANDONED FIELD

NO. 1 5 ABANDONED FIELD NO. 2

Figure 2



An increase of 7 percent pore space was associated with 700 percent increase in infiltration rate. Formation of a thin, compact crust on bare field soil surfaces hinders rainfall infiltration out of proportion to total difference in soil weight; and formation of very small cracks and pores greatly increases rate of gravitational water movement.

Summary

An old field regenerated naturally from abandonment by pine in 65 years was studied in relation to a chestnut oak stand, a white oak stand, and an abandoned field. Litter accumulation under the shortleaf pine stand had risen to 26,968 pounds per acre, compared to 19,661 pounds and 14,400 pounds for the chestnut oak stand and the white oak stand, respectively. Nitrogen in litter under shortleaf pine was greater than in that under chestnut oak or white oak; the pounds per acre were 409,377, and 227, respectively. Pounds nitrogen accumulation in the first 2 inches of the mineral soil for the same 3 wooded sites were 1,070, 1,066 and 989 pounds and for the abandoned field 604 pounds.

Although porosity of the old-field pine surface soil was only 7 percent greater than that of the adjacent abandoned field, its infiltration rate was about 700 percent greater.

Forest soil conditions under a shortleaf pine stand regenerated in 65 years from an abandoned field compare favorably with those under second-growth, oak stands whose soil has not been broken. The history of land use in this Muskingum silt loam area is an indication of the possibilities of forest and soil restoration in a large part of several southeastern Ohio counties.